A climate for change? The impacts of climate change on energy politics

Article (Accepted Version)

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1. Introduction

The geophysical phenomena of climate change impacts upon the existing organisation of energy economies and their attendant politics in multiple ways: At times magnifying and at other times dampening pressures on contemporary energy systems. What is very clear, however, is that energy is central to debates about climate change. Energy production and use account for two-thirds of the world's greenhouse-gas emissions (IEA 2015), while climate change is one element of what has been referred to as the 'world energy trilemma'.[1] This trilemma highlights the problem of simultaneously pursuing goals of improved energy access and accelerated growth, enhanced energy security and decarbonised energy systems in order to tackle climate change (WEC 2012).

In March 2017, UN Secretary General António Guterres referred to climate change as a 'threat multiplier' at a high level event on climate change and the Sustainable Development Agenda (Guterres 2017). This understanding of climate change was first mooted in a 2007 report by eleven high-ranking retired US admirals and generals (CNA Corporation 2007). Here the ex-military men argue that climate change will exacerbate and further complicate existing concerns over environmentally sensitive issues such as food insecurity, water scarcity and energy access (Brown, Hammill & McLeman 2007). That same year, the UN Security Council held a landmark debate on climate change, energy supply and security (UNSC 2007), and since then the concept has been deployed in a variety of settings as a means to both analyse and manage the relationship between the geophysical phenomena of climate change and the global energy sector.

[1] The world energy trilemma is one of four strategic studies carried out by World Energy Council. The trilemma finds its origin in the Council's definition of energy sustainability. This definition is based on three core dimensions – energy security, energy equity, and environmental sustainability. These three goals constitute a 'trilemma', entailing complex interwoven links between public and private actors, governments and regulators, economic and social factors, national resources, environmental concerns, and individual behaviours.

We argue here that viewing climate change as a 'threat multiplier' in this way does not adequately capture the relationship of climate change to energy systems and the international social and political formations that are intimately bound up with specific energy pathways. Rather than position climate change as external to human and social systems as such accounts tend to, in ways which abstract climate change from the its anthropogenic roots, we suggest it is internal to economic and social systems: it derives from them, and that this helps to explain the ways in which actors and institutions in the dominant energy regime seek to accommodate and manage the threat posed by climate change. That is, while capturing the multimodal impacts of climate change, the concept of climate change as a 'threat multiplier' fundamentally misconstrues the drivers of energy system change. Instead, we maintain that the geophysical phenomena of climate change are socially and politically mediated by actors with uneven power, capacity and divergent interests in order to support either incumbent or competing energy pathways. For example, the threat of climate change has been invoked to justify the accelerated decline of widely opposed energy sources such as coal, while at the same time justifying the expansion and updating of controversial technologies such as nuclear in some parts of the world (IEA 2016). While climate change intensifies and magnifies existing tensions and contradictions in the global politics of energy around the simultaneous pursuit of the objectives of growth, security and sustainability, it does not do so in a straightforward or unmediated way.

Given the nature of these tightly interlinked issues, we seek to locate climate change as part of a specific socio-natural relationship that has evolved over time and needs to be located historically rather than presented as a trans-historical and objective phenomenon (Bonneuil & Fressoz 2016). Rather than isolating and seeking to quantify climate change's importance as an independent 'threat multiplier' to energy systems, we highlight the composition of energy systems as complex historically bound assemblages. These assemblages are comprised of natural material resource flows extracted or harnessed from certain environments and spaces, leaving certain waste products and environmental impacts in return, via specific hardware, human labour, material and calculative technologies, institutions, infrastructures and financial flows.

The arrival of climate change as an issue of international political importance in the late 1980s did not bring about a rupture in global energy politics. Growing recognition of its seriousness, despite the efforts of major fossil fuel industries to discredit the scientific and economic case for action (Newell & Paterson 1998), instead triggered a series of political accommodations and re-alignments in the energy sector. These shifts were undertaken by actors both threatened by the challenge climate change poses to the sustainability of the fossil fuel economy, as well as those seeking to capitalise on the opportunities associated with an anticipated transition to a low carbon economy. In other words, the natural and social phenomena of climate change and its governance are both produced by, and change, the ways in which energy systems and (predominantly) capitalist political economies are organised. This unsettles the notion of climate change working as a 'threat multiplier' external to political systems. Understanding the impact of climate change on energy systems requires that we take seriously the necessary role of energy within the global political economy and the relationship between fossil fuels and capitalism. It must be analysed both directly through climate change impacts, and indirectly through the uses of political narratives of climate change to sometimes unsettle, and sometimes reinforce, particular energy pathways.

In this article we explore how the viability of particular energy systems and the circuits of production, exchange and consumption that they power are affected by climate change. In section 2 we look at the centrality of the energy sector and particularly fossil fuel use to both the contemporary global political economy and the global climate system and situate this discussion within existing literatures in International Relations (IR). In section 3, we highlight the differential impacts of climate change on energy systems via infrastructural disruption and the reduced viability of certain forms of energy production. In section 4, we focus on the invocation of climate change as a political narrative, and how this has been used to both accelerate and resist energy system transition.

2. Energy and fossil capital

Energy is the lifeblood of modern society, and is central to the contemporary global political economy through its relationship to growth, statehood, militarism and geopolitics (Huber 2013; Bromley 1991; Yergin 2008; Malm 2015; Mitchell 2011; Vitalis 2009; Parra 2004; Painter

1986; Labban 2008; Wrigley 2010). In spite of this, energy has often been neglected within the discipline of IR. Traditionally its role in international affairs has been reified and simultaneously naturalised - reduced to material resources external to the state and state formation. In Realist traditions energy is often simply the object of state competition (Ikenberry 1986; Deni 2015; Colgan 2013), while more Marxist renditions (Bromley 1991; Rees 2001) emphasise energy resources (particularly oil) as the focus of imperialism and exploitation. Bromley suggests for example: ‘Control of oil may be seen as the centre of gravity of US economic hegemony’ (Bromley 2005:227). By way of indictment of the debate about energy in the discipline, Van de Graaf et al (2016:4) maintain that Ernest Wilson’s claim in 1987 that work on the international dimensions of energy is ‘largely descriptive, atheoretical and noncumulative’ remains valid today. Against this background, how global environmental change and climate change in particular might alter and be changed by global energy politics has received even less attention (Falkner 2014).

Susan Strange’s invitation to take energy seriously in her seminal book on *States and Markets* (1988) suggests that as a discipline, International Political Economy (IPE) should be better placed than IR to address the interrelation of energy, social and political formations. Indeed, IPE arose as discipline distinct from IR in the shadow of the 1970s oil-price shocks. However, besides a very recent spike in interest (Di Muzio 2012, 2015; Di Muzio and Ovadia 2016; Van de Graaf et al 2016; Kern and Markard 2016), a mutual neglect by IPE scholars of questions of energy, and conversely by energy policy scholars of IPE, has frustrated a productive cross-pollination of insights. Given the centrality of energy to state power, geopolitics and the balance of power in the international system, international economic relations and the global politics of sustainability, this is particularly surprising and problematic.

We suggest here that any conception of climate change on energy systems must proceed from an anthropocene or ‘capitalocene’ perspective (Moore 2015, 2016 Malm & Hornborg 2014). Anthropogenic climate change is (by definition) a human condition, but not one produced by the homogenous mass of humanity. Some humans, in some places, at some times, under some socio-natural relations bear a greater responsibility for climate change, and other humans, in different places, times and conditions will bear the brunt of it. The anthropocene’s dialectical energy-society relation can be situated historically in a number of ways. For Wrigley (2010), Mitchell (2011) and Malm (2015), the development of the industrial revolution (the initially purported location of the anthropocene age) and its relation to fossil energy represents a qualitative turning point. While Wrigley argued that the development of industrial capitalism needs to be understood as enabled primarily by the exploitation of energy dense coal, Malm (2015) argues the converse relation – that a transition from water power to coal power during the industrial revolution in Britain occurred, not because of the realisation of coal as a superior source of energy, but rather due to the opportunity it afforded textile mill owners to further discipline and exploit labour by enabling the development of urban, steam-powered factories – workshops that regulated work rhythms, squeezed higher productivity from workers and allowed the exploitation of women's and children's labour (Malm 2015:76).

As Mitchell shows, however, the exploitation of labour through the exploitation of coal did not ossify socio-natural relations, and from the beginning of the 20th century the very material specificity of coal and its production enabled labour to exploit certain choke points in its production and distribution to fight for greater social protections and democratic freedoms through the use of the political technology of 'sabotage' (Mitchell 2011). Strikes at the coal face, railways and docks could exploit the requirement for concentrated energy and steam powered machinery to dig coal from the earth and then transport it to its ultimate destination.

The shift from coal to oil as predominant fuel source in the post-war years similarly represents a further qualitative shift. Again, disciplining labour through its removal from a transportation process now undertaken overland by pipeline (Mitchell 2011), and ushering in the 'great acceleration' in economic and population growth, food and materials production, consumption and their associated environmental damage (McNeill and Engelke 2016). The exploitation of oil and the simultaneous institutionalization of energy,[2] understood as a system of interchangeable power sources, were key to the development of the 'growth paradigm' (Dale 2011, Schmelzer 2016). Energy, largely in the form of oil, provided the material, conceptual and discursive fuel for the newly predominant post-war focus on the growth of national

[2] This institutionalization lagged behind the material abstraction of energy in the form of widespread electrification, divorcing final energy use from its specific source (Mitchell 2008). This is preceeded by an even earlier conceptual abstraction through the development and application of the new physics of the 19th century (Mirowski 1989, Illich 1974, 2010).

economies measured, defined and made comparable through the newly emergent systems of national accounts and GNP (Schmelzer 2016; Lane 2014, 2015; Mitchell 2011; Illich 2010).

As Kuzemko et al (forthcoming) note 'The reproduction of world economy relations is now routinely confronted by the often fractious politics of securing access to energy; the drive towards constituting a distinctively low-carbon economy; the recent rise in perceptions of a generic energy crisis; and the ongoing institutional reconfiguration of both demand and supply of international energy markets'. Climate change is at once invoked as a signifier of the unsustainability of 'fossil capital' specifically (Di Muzio 2012; Malm 2015; Bonneuil & Fressoz 2016), capitalism in general (Klein 2014; Moore 2015, 2016) or industrialism and growth fetishism more broadly still (Dale 2011, 2017). Energy is important materially, institutionally, technically and symbolically given its ties to economic growth, development ambitions and political legitimacy through the ability to provide energy security as well as status and standing in international society (Kuzemko et al 2016). In this sense it is not hard to understand why the growing recognition of the need to tackle climate change is an unwelcome development for most states, industrial actors and the networks of power that characterise energy regimes organised around and beyond the state. It is similarly unsurprising that there are many interests aligned against the notion that climate change should be allowed to disrupt what Di Muzio (extending Gill's 1995 notion of 'market civilisation') calls 'petro-market civilisation'. This highlights the way in which the current pattern of energy-intensive social reproduction is produced by the oil and gas sector in particular (Di Muzio 2012).

Yet, as we show in this article, there are many ways in which both the requirement for climate change mitigation and the reality of adaptation to climate impacts are increasing and amplifying both existing challenges and crises confronting global energy systems and the broader global political economy that this system engenders. This suggests the need to understand how the geophysical, social and political dimensions of climate change interact with incumbent political and economic systems as they relate to energy. At times climate change disrupts them and creates crises for the organisation and legitimacy of existing ways of ordering the world, revealing systemic vulnerabilities (e.g. the dependence on finite resources for the current production of food and energy or for trade and transportation). At other times opportunities are projected onto it to 'creatively destruct' in Schumpeterian terms: to make money from crisis or to organise new rounds of accumulation around 'climate compatible growth' (OECD 2011). This latter involves reworking and re-making energy assemblages in ways which can ostensibly address climate change without unsettling deeper structures of political and economic power.

Climate change can also produce further 'lock-in' (Unruh 2000) of incumbent energy systems. Seto et al (2016) show how the large capital costs, long infrastructure lifetimes and complex interrelationships between socioeconomic and technical systems mean that fossil-fuel based energy infrastructures are particularly prone to lock-in, of which they identify three major types. The first is associated with the technologies and infrastructure shaping energy supply and indirectly or directly emitting greenhouse gases. The second is institutional lock-in due to governance and decision-making impacting on energy production and consumption. The third refers to behavioural lock-in related to habits and norms associated with the demand for energy-related goods and services. Moreover, they argue that lock-in risks are exacerbated by the urgency of efforts to mitigate climate change.

This is a reading of incumbency not as a rigid and static set of structures for which climate change simply presents as an external 'threat multiplier', but as an assemblage of components that are held together in the face of the contradictions and vulnerabilities which climate change produces and exacerbates. This includes securing finance for 'un-burnable carbon',[3] protecting and expanding infrastructures in the face of resistance and civil disobedience, finding alternative technological options and fixes, ensuring institutional backing through states, regional and global institutions for business as usual trajectories in the face of evidence of their non-sustainability and through the construction and repetition of discourses which deny, ignore or obfuscate the contradictions around containing climate change and expanding a resource hungry global capitalist political economy.

3. The differential impacts of climate change on energy systems

Here we briefly explore the multiple, direct impacts of climate change on the energy sector. Despite the challenges associated with modelling the precise effects of changes to a complex

[3] This refers to reserves of fossil fuels whose extraction and release into the atmosphere are incompatible with the goals of keeping global warming at least below 2°C (McGlade and Ekins 2015).

climate system upon numerous aspects of the energy system, several general outcomes can be identified.

First, climate change is likely to have a variety of impacts upon the supply of energy. This may constrain and close down certain pathways while opening up others. There is also the possibility of substantial variations across regions and even within countries (IPCC 2014) as well as potential for stranded infrastructure (infrastructural assets that suffer from unanticipated or premature write-downs, devaluation or conversion to liabilities). One example of this is the declining long-term viability of hydropower in some African countries, such as Kenya, due to reduced rainfall (Newell et al 2014).

The IPCC Fifth Assessment Report also highlighted the potential impact of climate change on a variety of other renewable energy sources (IPCC 2014; Scharlemann et al 2016). There are potentially large variations in these impacts across and within regions. Altered soil conditions, precipitation changes and impacts on crop productivity in response to climate change could negatively impact the potential for bioenergy generation. In the case of solar photovoltaic (PV), solar resources may no longer be stable and could undergo decadal changes due to the distribution and variability of cloud cover. Statistically significant decreases in solar PV outputs could be seen in large parts of the world, alongside notable increases in large parts of Europe, south-east US and south-east China (Wild et al 2015). Climate change is not expected to significantly impact the global potential for wind energy production; however, changes may be expected in the regional distribution of wind energy resources. It is also not expected that the size or geographic distribution of geothermal or ocean energy resources will be significantly impacted by climate change (Scharlemann et al 2016). Conversely, climate change has the ironic effect of enabling further exploitation of fossil energy sources though the melting of Arctic ice sheets, enabling access to new oil frontiers for drilling and extraction, and whose consumption further accelerates climate change. As Walsh (2012) notes: ‘here’s the real irony: the most immediate impact of climate change-related Arctic ice melting will likely be the opening of vast new drilling territory for a thirsty oil industry’.

Second, climate change is likely to add to energy demand through changes to heating and cooling requirements. Peak electricity demand could increase, resulting in increasing requirements on energy infrastructure and potentially increased energy use for climate sensitive processes (pumping water for agricultural and municipal use, desalination). In their review of the literature Ciscar & Dowling (2014) argue that no conclusive predictions can be made about the expected net impact of climate change on the energy sector, though the general pattern seems to be that heating demand will decrease and cooling demand will rise.

Third, climate change increases the risks from 'natural' disasters to energy infrastructures (see contribution by Pant to this special issue). Both generation and delivery infrastructures can be impacted by sea-level rise and extreme weather events (IPCC 2014), affecting biofuel production for example. A striking example of how a natural disaster could play out is the impact of the tsunami on the nuclear facility at Fukushima and the effect this disaster had on the fate of the nuclear industry both in Japan and in Germany. Beyond nuclear, offshore infrastructures for oil, gas and wind are also susceptible to extreme weather events.

Production losses from thermal power plants are also anticipated, as well as efficiency losses from delivery infrastructures when temperatures exceed design criteria (IPCC 2014). Alongside this, some power generation facilities will be impacted by changes in access to cooling water (IPCC 2014). Overall then, the impacts of climate change on energy systems are expected to be diverse, impacting both supply and demand, and dependent upon the mode and means of power generation and transmission, as well as their susceptibility to extreme weather events.

4. The impact of climate change as a political narrative

The potential threat and impact of climate change on energy systems and the broader global political economy does not reside solely with the material impacts of climate change on energy supply, demand and transportation. As part of the dialectical and historically given relationship between energy and capitalism, a narrative of climate change as catastrophic and irrevocable has been deployed by some actors to both accelerate and resist energy system transition in multiple ways.

First, the current and projected effects of climate change can give rise to neo-Malthusian narratives around conflicts over diminishing resources in 'climate war' scenarios (Welzer 2012). Research positing these connections has been critiqued on a series of grounds including: that the correlations identified are spurious since they always rest upon coding and causal assumptions which range from the arbitrary to the untenable; that even if the correlations identified were significant and meaningful, they would still not constitute a sound basis for making predictions about the conflict impacts of climate change; and that such models reflect and reproduce a problematic ensemble of Northern stereotypes, ideologies and policy agendas (Bonds 2016; Selby 2014; Theisen 2017). Nevertheless, such narratives are potentially attractive to military actors as both part of a securitizing discourse on climate change and as organizations keen to find new roles for themselves as protectors of supplies of water and land for energy production around the world (CAN Corporation 2007; Duffield 2014; Hayes & Hayes 2014); and thereby securing the financial resources this would imply. Likewise, as Corry notes, risks can be repositioned as threats and 'exceptional measures are made permanent and introduced to deal with merely potential, hypothetical and less-than-existential dangers' (Corry 2012: 235). This is the danger others have noted in this special issue of framing climate change as a 'threat multiplier': that it implies and validates a need for military responses to contain threats to security that bypass public political discussion and potential contestation in favour of a 'high politics' of threat reduction and resolution.

Many scholars have also observed the growing securitization of energy whereby threats to the energy sector from other states are presented as national security threats, intensifying strategic and economic competition between states over energy supplies by tying energy to a national security 'us vs them' scenario (Kuzemko et al 2016; Natorski and Herranz-Surrallés 2008). This extends to corporations and the branding of competitive economic threats as issues of national security, an example of which is the China National Offshore Oil Corporation (CNOOC)'s 2005 bid for US energy company Unocal which elite actors in US responded to by calling for presidential action on the grounds of 'national security' (Nyman 2014).

Similar concerns have been articulated about the ways in which climate change serves to reconfigure geopolitical calculations in the rush for energy resources (Klare 2008). A reluctance on the part of powerful states to redirect energy systems and unsettle incumbent interests implies scenarios in which military interventions, commercial and coercive diplomacy are used to secure future supplies of energy overseas. This can be observed in land grabs to secure bioenergy supplies[4] or wars over oil (Kaldor et al 2007). As well as overt grabs and 'accumulation by dispossession' (Harvey 2004), other effects of this include exacerbating inequalities via e.g. competition for land for biofuels where there are direct trade-offs between land used for fuel as opposed to food (Smith 2010). Temporary climate 'solutions' such as these mean crises can be moved around through spatial and temporal fixes over time and across the globe (Harvey 1981).

Second, as well as representing a threat to the current fossil fuel powered global geopolitical configuration, significant efforts have been made to reposition the threat posed by climate change as an opportunity. This includes attempts to reconcile climate change with capitalism through ecological modernisation narratives around green growth (Bailey et al 2011, Wanner 2015), as well as advocating for a fundamental diversion of technology, finance and production towards low carbon goals (Newell & Paterson 2010). Whereas 'niche' actors have long made this argument, it is clear incumbent actors, including the fossil fuel majors (the world's eight largest oil companies), are also accepting the need for change. The degree of change required to take advantage of this apparent opportunity is not at all clear however. From the OECD to the World Bank, prominent global governance institutions have been at pains to show that continued economic growth, and the energy required to power this, is not only compatible with tackling climate change, but is a prerequisite to tackling the issue given the requirements for finance, technology and new forms of production (OECD 2011; World Bank 2012). This focus on expansion of supply, rather than reduction in demand, upon changing patterns of production and consumption but not levels, even among governments that accept the 'planetary boundaries' framing (in the EU for example), goes to the heart of some of the contradictions facing states in a growth-oriented capitalist global political economy.

These arguments are reliant upon an absolute decoupling of economic growth from energy and material throughput that while previously asserted (e.g. Handrich et al 2015; UNEP 2015), are now widely considered to be impossible (Giljum et al 2014; Knight & Schor 2014; von Weizsäcker et al 2014; Mir & Storms 2016, Ward et al. 2016; Schandl et al 2017). Moreover, in the case of oil companies, as well as investing some of their capital in renewable energies,

[4] For a review of European corporate and financial entities involved in land-grabbing outside the EU see e.g. Borras Jr et al 2016; Bracco 2016. On land-grabbing and food security in Africa see e.g. Mutopo et al 2011. 2016.

this has involved trying to control the pace of low carbon developments by continuing to argue for a major role for fossil fuels, and the use of 'transition' technologies and fuels such as fracked gas.

The need to address climate change has also been invoked to drive more disruptive Schumpetarian 'waves of creative destruction' as restless finance seeks to unsettle incumbent power (Perez 2002; Newell 2015). As discussed further below, mix of financial and civil society actors are driving this move towards 'divestment' from fossil fuels and reallocation of capital towards low carbon energy. Carlota Perez's (2002) work reminds us of the key role of finance in supporting previous historical transitions – the 'grand experiments' she refers to 'when unrestrained finance can override the power of the old production giants and fund the new entrepreneurs in testing the vast new potential'. Though current debates about transitions and transformation place technology centrally in their vision of how to move towards a lower carbon model of development, Perez shows that finance capital has previously been crucial to challenging and dislodging the power of incumbents. Examples include the technological revolutions produced in the industrial revolution, what she refers to as the 'age of steam and railways', and around 'oil, automobile and mass production' in the Fordist era (Perez 2002). Indeed, as Arrighi notes: 'Throughout the capitalist era financial expansions have signalled the transition from one regime of accumulation on a world scale to another. They are integral aspects of the recurrent destruction of 'old' regimes and the simultaneous creation of new ones' (2010: xi-xii).

As well as being mobilised in order to disrupt existing regimes, climate change also magnifies, consolidates and extends particular types of global energy politics by being invoked to lend further weight to neoliberal policy reforms. It is drawn upon by donors and Multilateral Development Banks (MDBs) as a rationale for market-led private transitions – opening up markets to 'clean energy' investment where state utilities are presented as lacking the finance and experience to undertake them efficiently and effectively. The case of Kenya is indicative in this regard. The need for private sector investment and technology for achieving low carbon development goals validates power sector reforms and the unbundling of 'inefficient' state service providers as part of 'neoliberal energy transitions' (Newell and Phillips 2016). Likewise globally, there have been calls from the World Bank and OECD for an 'energy' trade round and the need to reduce subsidies (Newell 2009) under the banner of addressing climate change.

Techno-fixes and 'end of pipe' solutions also feature highly in contemporary policy debates about the implications of climate change for energy systems. Examples include Carbon Capture and Storage, used to justify continued and expanded use of coal, even if its assumed adoption and roll-out is not justified by the development and availability of the technology to date. Many of the ambitions of the 2015 UNFCCC Paris agreement about net-zero emissions also imply the widespread use of NETs (negative emission technologies), the most commonly proposed form of which are BECCS (Biomass Energy with Carbon Capture and Storage) which are utilised in more than 80% of IPCC pathway projections. BECCS involves the mass plantation of trees to absorb carbon dioxide from the atmosphere. Even in spite of the technological issues involved here, for these to work at the scale necessary plantations three times the size of India, consuming one third of the planet's arable land, would need to be created (Anderson 2015; Anderson & Peters 2016), potentially driving further land grabs.

Similarly extreme are the forms of geoengineering being proposed and built into scenarios and assumptions to reduce the need for structural change (POST 2009). In some instances the imperative of tackling climate change is invoked to re-legitimise a role for controversial technologies. Examples include the nuclear renaissance in Asia in particular (led by China, India and Korea)[5] and the branding of fracked gas as a 'transition fuel' between coal and oil and renewables. In this sense climate change gets invoked as catastrophic master discourse for 'post-political reasons' (Swyngedouw 2010) to bypass conflict and opposition to controversial planning decisions and technology such as fracking, nuclear and geo-engineering. The urgency of addressing climate change is also mobilized to side-line more radical and disruptive calls for reform of existing systems of energy production and consumption including their democratization (Fairchild and Weinrub 2017), reductions in energy demand through conservation, and the need for transitions to address issues of social justice (Swilling and

[5] The IAEA predicts that nuclear power will continue to expand globally in the coming years, even as the pace of growth slows amid competition from low fossil fuel prices and renewable energy sources. According to IAEA projections, the world's nuclear power generating capacity could expand to 390.2 GW(e) by 2030 in the low case from 382.9 GW(e) last year, while in the high case it's projected to rise to 598.2 GW(e) (IAEA 2016).

Annecke 2012) on the grounds that the urgency necessitates working with existing structures and institutions.

The relationship of climate change to energy is also intertwined with dependencies upon other components of nature: water, forests and land - all of which are affected by climate change (through shifting rainfall, changes to soil quality and productivity etc) throughout water and carbon cycles. Thus it is not feasible to take climate change 'out of ecology'. This is captured in the idea of the 'nexus' around energy-water-food and how interventions in one domain impact upon all others (Wichelns 2017). We noted above how hydropower futures are increasingly compromised by shifting rainfall patterns, while biofuels are presented as a solution to climate change despite the energy and water inputs they require (Scharlemann et al 2016). This indicates how boundaries are drawn around certain technologies and energy pathways in order to position them as 'low-carbon'.

Third, the need to mitigate climate change potentially changes the political and economic and environmental viability of resource trajectories, magnifying and intensifying existing struggles over energy futures and potentially shifting the balance of power among actors in the energy domain in ways which represent potential embryonic shifts away from fossil-fuelled capitalism. For example, we have seen how in many countries the need to de-carbonise the energy system has re-balanced the conflict between fossil-fuel incumbents in the oil and coal sectors and niches promoting renewable energy over state support to energy sectors. Perhaps most prominently Germany's transition to a low carbon economy ('energiewende') stands out, but across the world this dynamic plays out to varying degrees in debates about Feed-in Tariffs and the balance of subsidies committed to fossil fuels as opposed to renewable energy (Lockwood 2015).

We can also observe this potential to bring about shifts in power in relation to the phenomena of fossil fuel reserve assets that cannot be burned being 'stranded', noted in section 3 above (McGlade and Ekins 2015). This generates pressures from activist shareholders upon firms to disclose and divest, whereby even recalcitrant actors such as Exxon are forced to demonstrate to shareholders why their assets are not stranded (Newell 2008) amid shifting perceptions among some investors about the long-term future of fossil fuels. Carbon Tracker (2013) suggests that as much as 80% of coal, oil and gas reserves are now un-burnable if climate targets are to be met. A write off of assets of this magnitude within the energy industry presents the possibility of global financial destabilization and unknown impacts on a carbon-fuelled global political economy. Alongside this threat, the falling costs of solar energy production in particular also make renewables cost competitive with fossil fuels in many markets.

Since it is invoked as a campaigning motif, and meta-narrative regarding the unsustainability of the current global political economy (Klein 2014), climate change also gives rise to new mobilisations across movements and new forms of resistance politics that shape directly and indirectly the energy pathways of countries: putting some projects and investments off-limits. We can see this in the divestment movement noted immediately above, as well as movements to leave fossil fuels in the ground. Concretely this finds expression in resistance to infrastructural projects from indigenous and environmental movements, such as the extension of the Canada-US Keystone pipeline distributing oil from Canada to refineries in the US, but also in Europe in mobilisations against gas in Italy and anti-fracking movements in the UK.

The extent to which states are able to resist the role of climate change as a driver of structural change in the energy sector depends upon many things, most obviously the degree of policy autonomy and developmental space (Wade 2003; Gallagher 2005) they are able to exercise to determine their own energy policies, which is a function of aid dependency, trade ties and relations to large investors. For example, a key driver of initiatives towards 'climate compatible development' (Mitchell and Maxwell 2010) in the energy sector is bilateral and multilateral donor climate funds. This is actively re-shaping energy pathways, even if the heightened interest and investment power of so-called rising powers provides continued channels of finance for fossil fuel trajectories with fewer, if any, conditions (Power et al 2016).

5. Conclusion

This article has explored how the viability of particular energy systems and the circuits of production, exchange and consumption that they fuel are affected by climate change in multidimensional ways. First, we established the centrality of the energy sector and particularly fossil fuel use to both the global political economy and the global climate system. Second, we reviewed evidence of the differential, direct impacts of climate change on energy systems via infrastructural disruption and the reduced viability of certain forms of energy. Third, we analysed the ways which climate change is invoked as a political narrative to both accelerate and resist energy system transition.

The analysis has revealed the multitude of ways (geophysical, material, financial and symbolic) in which climate change impacts upon global energy politics: exacerbating and intensifying some challenges and forms of energy politics and creating new ones. It is not so much that climate change multiplies external threats to energy systems, as much as it forcefully reasserts the internal, ecological relationship of energy policy to broader natural and social systems. Decision-making on energy policy increasingly has to take into account the need for development to be both low carbon and climate change resilient, as well as pursuing traditional goals of tackling energy poverty and security. This is not to diminish the ways in which the geophysical impacts of climate change might further undermine the energy security of some of the world's poorest groups, through impacts on energy infrastructures such as dams in areas of reduced rainfall and electricity grid outages. Nor is it to disregard the notion that climate change adds to the issues states, corporations and civil society actors have to address.

However, climate change does not act as an external, unidirectional (albeit multidimensional) 'threat multiplier' to energy systems and politics. Instead, it heightens trade-offs and contradictions around growth, the limits of technology and the current organisation of the global economy internal to contemporary capitalism, while also being invoked to advance and reify the preferred visions and strategies of elite managers of the global economy. The trade-offs that lie at the heart of our climate changed energy politics are hardly new, and the ways in which states and corporations use their power to overcome limits to resources, capital, labour and land, often at the expense of the poorest countries and social groups within them, provides a shorthand for trends in energy politics since at least the industrial revolution, if not before.

Whether climate change is identified as a threat, by whom and to what, and the types of responses and interventions that are then justified by that construction, are in the final analysis a function of social and political processes as well as geophysical and material ones. Climate change needs to be understood as a product of, and in relation to, the political and economic institutions which simultaneously create and seek to contain this threat. Rather than passively accepting the 'natural' re-orderings that climate change imposes, or the construction of the threats this inevitably implies for 'us' as a homogenous mass of humanity, it becomes both possible and necessary to approach energy politics in new ways. It is critical that issues of responsibility and justice within and between nations, international institutions and global corporate actors are front and centre in any discussion of the threats posed by climate change.

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